PHOTOSYNTHETIC ACTIVITY OF SPECIES IN A BEECHWOOD II. SPRING – SUMMER ASPECTS

by

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Introduction

In our experimental series we investigated the photosynthetic activity of the plants growing in the herb layer of an old beechwood at Farkasgyepü (Bakony Hills/Hungary) with special regard to the essential alteration of light environment of these plants when the wood gradually gets leafed. In the early spring by end of March, beginning April the direct illumination is 4 – 20 thousand lux in the herb layer, in the first half of May it is around 3 thousand lux, by mid-June only around 400 – 1000 lux. We measured the photosyntetic activity of the mostly shadow-plants growing in the herb layer of the beech wood – in their natural light environment, after this we were interested in their photosynthetic capacity on high light intensity.

This paper is the continuation of the first paper dealing with the early spring geophytons. The description of carrying out the measurings, the sampling, the adapted methods see in the previous work (D r a s k o v i t s 1979a).

We publish the photosynthetic capacity values in cpm referring to 1 mg dry weight (Table I) resp. to 1 square cm leaf area (Table II). The cpm values presented in the tables are average values deriving from three times repetition (Thus from 27 measuring data) of 9 individuals of a single species. The sampling dates were: 16 – 20 April, 8 – 11 May, 14 – 17 June, 13 – 15 October, 1979. The investigated plants: *Corydalis cava, Dentaria enneaphyllos, Mercurialis perennis, Carex pilosa, Viola silvestris, Oxalis acetosella, Asperula odorata, Lamium galeobdolon, Dentaria bulbifera, Circaea lutetiana, Impatiens noli-tangere, Stachys silvatica, Hedera helix.*

Table I

Photosynthetic activity of species in the underwood 10^4 cpm/cm²/min.
Farkasgyepü, 1979.

		Illumination klux						
		0.4–0.8	3	12	20	26	40	60
Carex pilosa past year's	19. IV.			19.5		22.6	4.9	
Carex pilosa this, year's	19.IV.			24.1		22.8	28.2	
	10.V.		13.4					33.9
	14.VI.	2,27			15.7			
Viola silvestris this year's	19.IV.					25.1	8.87	
	10.V.		5.41					64.7
	14. VI.	1.59			12.5			
Oxalis acetosella this year's	19.IV.					23.4	38.5	
	10. V.		8.58					9.13
	14.VI.	27.8					9.2	
Corydalis cava	10. V.		13.8					57.5
Dentaria enneaphyllos	10. V.		9.71					49.3
Mercurialis perennis	10. V.		5.32					28.5
Asperula odorata	10. V.		8.64					32.0
	14. VI.	3.0			16.1			
Lamium galeobdolon	10. V.		6.58					57.1
	14. VI.	2.25			15.5			
Circaea lutetiana	14. VI.	1.84			19.8			
Impatiens nolitangere	14. VI.	1.46			21.6			
Stachys silvatica	14. VI.	1.31			27.8			
Hedera helix	14. VI.	1.28			21.4			
Dentaria bulbifera	10. V.		15.5					58.1

Table II

Photosynthetic activity of species in the underwood 10^4 cpm/mg/min.
Farkasgyepü, 1979.

		Illumination klux						
		0.4–0.8	3	12	20	26	40	60
Carex pilosa past year's	19. IV.			2.62		3.04	0.66	
Carex pilosa this year's	19. IV.			6.06		5.73	7.08	
	10. V.		4.21					10.6
	14.VI.	0.53			3.69			
Viola silvestris tihs year's	19. IV.					9.22	3.16	
	10. V.		1.70					20.3
	14.VI.	0,90			7.10			
Oxalis acetosella this year's	19. IV.					18.3	29.4	
	10. V.		6.06					6.45
	14. VI.	19.7					6.42	
Corydalis cava	10. V.		6.5					27.1
Dentaria enneaphyllos	10. V.		5.9					20.4
Mercurialis perennis	10. V.		4.1					21.5
Asperula odorata	10. V.		3.48					11.3
	14. VI.	1.41			7.61			
Lamium galeobdolon	10. V.		3.10					26.9
	14. VI.	1.59			10.9			
Circaea lutetiana	14. VI.	1.30			14.0			
Impatiens nolitangere	14.VI.	2.07			13.5			
Stachys silvatica	14. VI.	2.30			13.1			
Hedera helix	14. VI.	0.48			7.94			
Dentaria bulbifera	10. V.		8.74					33.2

Results and discussion

Our method adapted to the measuring of the photosynthetic activity gives the C^{14} quantity incorporated, measures the activity proportional to the brutto photosynthesis. It is suitable to the comparison of the photosynthetic activity of different species, to the collation of the photosynthetic activity of the light- and shadow-plants, to the tracing of the phenological as well as daily rythm etc.

	Herb layer of the wood				Clearing			
Air temperature (C°-centigrade) in the air-space of the leaves	6	11	14	17	8	14	17	23
CO_2 concentration (%) of the air in the air-space of leaves	0.032	0.038	0.047	0.041	0.031	0.032	0.032	0.033
	Apr. 2.	Apr. 19.	May. 10.	Jun. 14.	Apr. 2.	Apr. 19.	May. 10.	Jun. 14.

On basis of investigations in natural environment and phytotrons the advantageous temperature is the range between 15 – 20 centigrades from the point of view of photosynthesis of the forest plants, then is namely the photosynthesis not temperature-dependent because the biochemical reactions do not limit it only the physical barriers of the gas-exchange (Björkman – Pearcy 1971). The CO_2 concentration of the air surrounding the plants naturally influences hardly the intensity of the photosynthesis in function of the air temperature, O_2 concentration as well as interaction the higher concentration of CO_2 acts always advantageously to the photosynthetic activity since it hinders both on low and high light intensity the photosynthetic inhibition arising form the 21% O_2 concentration of the normal air. This inhibition is also decreased by the raising of the temperature (indirectly by the biochemical effect of the cell).

Our CO_2 concentration measuring show that the CO_2 concentration of the air is higher in the herb layer of the wood than in the normal air.

We measured with the cassette taken into the leaf litter CO_2 concentration of 0.051% too!

Tendencies of the reference to weight resp. area, similarly to the early spring measurings entirely correspond; there is a slight difference caused by the "heavy" leaf of *Carex pilosa* and the "thin" leaf of *Oxalis acetosella*. In the low light intensity range the most plants have shown a realtively low photosynthetic activity decreasing during the vegetational period. In the high illumination range in turn we got different plant response reactions by different species. Our general observation is that the overwintwring leaves *(Carex pilosa, Viola silvestris)* are less active; on high light intensity they practically do not photosynthetize.

In the following we survey the photosynthetic activity of the investigated plants on different light intensities.

Carex pilosa

The overwintering leaves live till mid-April, later on they wither soon, got desorganized. Leaves of the two leaf generations react differently to the increasing of illumination. The photosynthetic activity of the overwintering leaves exceeds in the low illumination range namely in the natural underwood light environment that of the this year's leaves. Their photosynthetic activity decreases in turn when the illumination gets raised, according to our measurements they do not photosynthetize by 40 thousand lux anymore, they present a shadow-leaf character. In sense of our previous pigment-ecological investigations the pigment content of the standing the winter leaves is higher which is also a shadow-leaf peculiarity (Draskovits – Fekete 1976).

In contrary to them the photosynthetic activity of the this year's young leaves is more of sun-leaf character; the photosynthetic capacity increases with the increase of the illumination up the 60 thousand lux certainly. The photosynthetic capacity of the this year's young leaves increases generally by the increase of the are of the leaf, a great leap can be observed in the period between mid-May and mid-June in the low illumination range (i.e. between 400 lux and 3000 lux).

Viola silvestris

The overwintering leaf reacts to the increasing illumination by decrease of the photosynthetic activity, the this year's leaf reacts to the same effect by increasing its photosynthetic activity similarly to the behaviour of the two leaf generations of *Carex pilosa*. The past year's leaf does not function on high illumination(40 thousand lux $0.005 \cdot 10^4$ cpm/cm^2), the young leaf in turn acts very intensively ($40.3 \cdot 10^4$ cpm/cm^2). In summer in the underwood of the forest come fully into leaf in the low illumination range we measured low photosynthetic activity which moderately increased by the increase of the light.

Oxalis acetosella

In early spring beginning April the two leaf generations may be clearly distincted but later on newer leaves develop continuously thus when sampling it became difficult to collect leaves of possibly the same age and physiological condition. Thus it proved to be a problematical plant, when evaluating the results.

In connection with other *Oxalis* species *(Oxalis oregana)* Björkman (1968) mentions similar difficulties. It arises perhaps from this circumstance that we did not find the difference in the photosynthetic activity between the leaf generations observed in the two other species. The this year's leaves did not react uniquely to the increase of the light during the observed period of the vegetational stage (end of March – mid June). In April the photosynthetic activity gradually increases as a response to the gradually increasing illumination as in the sun-leaves.

In May we measured almost identical photosynthetic activity at both 6 and 60 thousand lux. Till June the situation turns: the leaves *Oxalis acetosella* react typically as shadow-leaves with a maximal intensity in the 4–900 lux light range!

The *Oxalis acetosella* as in our previous cenological and light-ecological investigations too has shown a shadow-leaf character during greater part of the year (Draskovits 1979b).

If we observe the tendency of the photosynthetic activity values in the spring and summer samples, being high of the latter is remarkable by low illumination.

According to our opinion the leaves of the summer samples developed later in the underwood of the already darker forest and are typical shadow-leaves. In the low light range they exceed the photosynthetic activity of every investigated other species. In contrary to this the leaves of the spring sampling developing in the clear forest show naturally the light-photosynthetic activity reaction characteristic to the sun-leaves.

When analyzing the peculiar photosynthetic activity of the *Oxalis acetosella* leaves we have to count with the domination, summarization of more effect combinations as the ontogenic development, age of the leaf, the quantity of light and its qualitative alteration reaching the herb layer of the wood, the alteration of the temperature of surrounding air of the plant, the change of the aspect and so on.

In case of the three above discussed species leaves of two leaf generations function synchronously. Common peculiaritycs of the three species that in early spring (in the low light range) the photosynthetic activity of the two leaf generations is rather similar, that of the past year's leaf exceeds that of the this year's young leaf.

The geophytons are from many points of view special members of the herb layer beech wood (Gorishina 1975, Szőke – Draskovits 1979, Draskovits 1979a).

Some of them had still green leaves when sampling in May thus we could draw into our investigations the *Corydalis cava, Dentaria enneaphyllos* and the *Mercurialis perennis.*

In our early spring measuring series we adjusted our activity even to the flowering of these species.

Their photosyntetic activity was then vivid in both the lower and the illumination ranges. In their later phenological stage, after the ripening, resp. dropping the fruit they kept still their increased photosynthetic activity level in every illumination range. It is remarkable that when they live already in the relatively darker wood, their photosynthetic reaction given to high light remains still high, they react to great light intensity with increased photosynthetic activity. It seems that their always high photosynthetic activity is not or at least not only the consequence of their actual light environment. The leaves of the early spring geophytons adapted not only to a given light environment – an early spring wood of high illumination – but their photosynthetic activity alters also keeping in step with the gradual light decrease. Their potential photosynthetic capacity is steadily high, it is possible that this is an also genetically fixed adaptational feature. The same leaves on the other hand utilize very well the low light range within they live in the second half of their life. Till in the early spring, in the underwood of the leafless forest the leaves of the geophytons get often high illumination, then from the second half of April it is more and more less. The illumination of the herb layer is namely less intensive but more uniform than in the early spring (Draskovits 1975). The high potencial photosynthetic activity experienced in the high light range seems to be an adaptation to the actual environmental circumstances in spring and the high potancial photosynthetic activity remaining still later on could be its genetical fixation.

The values of the photosynthetic activity of the *Asperula odorata* and *Lamium galeobdolon* are similar to each other, the tendency of their reaction given to the alteration of light corresponds too, the photosynthetic activity of the leaves increases parallelly with the increase of the illumination.

The higher photosynthetic activity of the species *Impatiens noli-tangere*, *Circaea lutetina* and *Stachys silvatica* flowering in the phenorythm the laters in course of the summer sampling appears in first line in the intense light range.

Dentaria bulbifera

The *Dentaria bulbifera* in flowering stage showed a very high photosynthetic activity in both the low and high light ranges.

Hedera helix

The photosynthetic activity of the *Hedera helix* is in comparison to the other species rather small – it is possible that this is a feature partly of the evergreen leaves. On the other hand we determined the photosynthetic activity of every other species in their flowering stage, that of the Hedera helix only on a plant being in the vegetative condition since this does flower on this biotope.

We note that our results derive from the 1 minute fixation of the activity of leaves thus indicate not the lasting reaction of the plants but the short period capacity. The *Corydalis cava* tolerates, perhaps utilizes the 60 thousand lux illumination but it is naturally non-viable on a biotope having this general illumination not only because of the stabilization of the light inhibition but because of the desorganization resulting in both the chlorophyll and chloroplast too.

The character of the photosynthetic activity of the plants is decisively determined by that light environment in which they live. The width of the light tolerance is a function of a phylogenetical adaptation. It is known from numerous investigations of Björkman and coll (1963) that the potencial width of the photosynthetic character depending from the light intensity of the singular plant individual differs hardly in case sun and shadow-plant, nay in individual of the same species (ecotypes) living in two different light environments. We established with our investigations that the photosynthetic activity of the leaves of underwood plants in beeches, its width did not narrow down to that average light intensity range in which they generally live but they responde with high potencial photosynthetic activity ot the effect of extraordinary high light.

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